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ABSTRACT

The purpose of this study was to contribute to greater understanding of the mathematics anxiety construct by: (a) identifying the independent dimensions underlying the item responses on the Math Anxiety Rating Scale (MARS); (b) developing factor scales to measure these dimensions; and (c) determining if specific personal and academic background variables can effectively serve as predictors of math anxiety as defined by the factor scales. The MARS was administered to 197 college students, and the responses were factor analyzed. Twenty-one factors were found; the first two components accounted for approximately 33% and 7% of the variance in MARS scores. The first item was labelled Math Test/Course Anxiety, while the second item concerned Numerical Task Anxiety. More anxiety was stimulated by mathematics test items than by numerical task items. Analysis of variance procedures indicated that students who had taken Algebra II in high school experienced significantly less math anxiety than students who had not taken Algebra II, and those with A's and B's in Algebra or Geometry experienced significantly less math anxiety than did students with poorer grades. It is suggested that student performance in high school mathematics courses be monitored, and early intervention provided. (MNS)

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IDENTIFICATION OF THE DIMENSIONS AND PREDICTORS OF MATH ANXIETY AMONG COLLEGE STUDENTS

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IDENTIFICATION OF THE DIMENSIONS AND PREDICTORS OF MATH ANXIETY AMONG COLLEGE STUDENTS

Increasing numbers of colleges and universities are revising their admission requirements to include more high school courses in mathematics. College and university officials assume that more courses in math will increase the probability that students will do well in college level courses. In addition, there is general consensus among educators that students who take appropriate math courses in high school and in college broaden the range of careers from which they can choose.

Unfortunately, some students develop emotional and intellectual blocks toward mathematics which make success virtually impossible. For these students, math represents such a negative experience that they actively seek to avoid it. As a result the students do not acquire the facility in math that would permit them to expand the range of career options available to them.

The construct frequently used to explain poor performance and avoidance of math courses in high school and college is math anxiety. Richardson and Suinn (1972) define math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Lazarus (1974) used the term, "mathophobia", to describe this phenomenon. According to Lazarus, a person is mathophobic if he "strongly dislikes math in school, goes out of his way to avoid it, regards math as a sort of cabalistic mystery beyond his

access or comprehension, or speaks openly of his aversion to it" (p. 52).

The growing body of research on math anxiety seems to reflect four clear and distinct concerns by researchers. First, some researchers (Fennema & Sherman, 1976; Richardson & Suinn, 1972; Sandman, 1974) were stimulated to develop instrumentation to measure math anxiety. Other researchers (Betz, 1978; Resnick, Viehe, & Segal, 1982) attempted to document the prevalence of math anxiety and its relationship to other variables. A third group of researchers (Resnick, Viehe, & Segal, 1982; Rounds & Hendel, 1980) seemed to focus on understanding the phenomenon of math anxiety more clearly by studying its dimensionality based on specific measures of the construct. Finally, several investigators (Addleman, 1972; Hendel & Davis, 1978; Hyman, 1973) tested intervention strategies for the reduction of math anxiety.

Of the four concerns reflected in the literature on math anxiety, the third (underdstanding the phenomenon of math anxiety) may well be the most critical area in need of further development. Results from studies on math anxiety have been inconclusive and sometimes conflicting. For example, some studies have reported that problems of poor performance and math avoidance are more common among females (Ernest, 1976; Rounds & Hendel, 1980; Tobias, 1976). Tobias (1978) even speculates that women and black males avoid mathematics because of some pervasive ideology that math and science are men's (specifically white men's) turf. However, no sex differences were found in a recent study of college freshmen by Resnick, Viehe, and Segal (1982).

While speculation abounds that math anxiety is more prevalent among blacks, no studies have seemed to even attempt to confirm that speculation. Perhaps the only meaningful conclusion which can be drawn from the present literature is one consistent with findings from a study by Betz (1978). In that study Betz (1978) found that math anxiety occurred frequently among college students and that it was, indeed, more likely to occur among women and among students with inadequate high school math backgrounds. Before empirical confirmation of the causes and effects of math anxiety can be obtained it is imperitive that researchers seek some consensus on the conceptualization of math anxiety. Definitions abound as to what math anxiety is. However, questions do remain as to whether math anxiety, as measured by the psychometrically sound Math Anxiety Rating Scale (MARS), is a unidimensional or multidimensional construct (Resnick, Viehe & Segal, 1982; Rounds & Hendel, 1980).

The purpose of the present study was to contribute to greater understanding of the math anxiety construct by (a) identifying the independent dimensions underlying the MARS item responses, (b) developing factor scales to measure these dimensions, and (c) determining if specific personal and academic background variables can effectively serve as predictors of math anxiety as defined by the factor scales.

Method

The Math Anxiety Rating Scale (MARS), a popular math anxiety instrument developed by Suinn, Edie, Nicoletti, and Spinelli (1972), was used to measure math anxiety in this study. The MARS

is a 98 item self rating scale typically administered in groups but which can also be administered individually. Each item on the scale represents a situation which may arouse anxiety within a subject. The subject decides on the level of anxiety associated with the item and reports that decision by checking one of five boxes next to the item: "not at all", "a little", "a fair amount", "much", or "very much". The responses are converted to numerical form by assigning the weights,1,2,3,4, or 5, respectively to each of the five possible responses. The number of checks for each of the five possible responses is multiplied by the corresponding weights (1 through 5). The sum of the products provides the total score for the instrument.

In addition to the MARS score the following personal and background information was also obtained for each subject in the study: age, sex, race, location of residence, total family income, number and type of math courses taken in high school, grades in Algebra and Geometry in high school, and whether or not encouraged to take math courses in high school by teachers and counselors.

The subjects were one hundred and ninety seven college students selected from a pool of students enrolled in Introduction to Psychology classes at a middle-sized state university. The Introduction to Psychology classes were selected because that course is listed as one of the General Education Requirement options. For that reason students enrolled in this class usually reflect a cross section of disciplines. The subjects in this study reported that they had either declared

majors in or were leaning towards: Computer Science, Math, History, English, Languages, Education, Social Work, or Psychology. Several subjects indicated that they were generally undecided. No single discipline seemed to be overrepresented among the subjects. Thus, the sample approximated the general population of freshmen and sophomores enrolled at the university in terms of major or discipline.

Subjects were asked to respond to the MARS and to an attached demographics sheet. Prior to administering the instrument they were told that their involvement would contribute to a better understanding of the attitudes students in high school and college have towards math.

Results

To identify the dimensions of math anxiety in the population of college students studied, the responses to the MARS items were factor analyzed using principal components analysis. Application of the Mineigen criterion yielded 21 factors. The first two components accounted for approximately 33% and 7% of the variance of the MARS scores respectively. Factor 1 had an eigenvalue of 32.63; the eigenvalue for factor 2 was 6.62.

The first component was defined by 34 items with factor loadings equal to or greater than .60. Of the 34 items, 13 (or 38%) reflected apprehension about taking a test in mathematics or about receiving the results of mathematics tests. The factor loadings (of the math test anxiety items) ranged from .61 to .76 with a mean loading of .68. The remaining items in Factor 1 reflected math course related activities. Factor 1 was therefore

labelled Math Test/Course Anxiety. Items illustrative of this factor are presented in Table 1.

Insert Table 1 about here

The second component was defined by 7 items with factor loadings equal to or greater than .48. The items comprising this factor reflected fear and apprehension about executing a numerical task. The factor loadings ranged from .48 to .66 with a mean loading of .54. Factor 2 was labelled Numerical Task Anxiety. The MARS items that comprised Factor 2 are presented in Table 2.

Insert Table 2 about here

The patterns of the loadings in Factor 1 and Factor 2 suggested the construction of two scales to measure Mathematics Test Anxiety and Numerical Task Anxiety. The Math Test Anxiety Scale included 17 items while the Numerical Task Anxiety Scale consisted of 7 items. The item composition of the scales and the means and standard deviations for the sample are presented in Table 3 and Table 4.

Insert Table 3 and Table 4 about here

Very clearly, more anxiety was stimulated by math test related items than by numerical task items. Mean ratings of the

items comprising the Math Test Anxiety Scale ranged from "a little" (2) to "a fair amount" (3) of reported anxiety. Mean ratings of the items making up the Numerical Task Anxiety Scale reflected "not at all" (1) or "a little" (2) reported anxiety. Although the differences between the scales seem to be dramatic in terms of reported anxiety, neither scale reflected overwhelming amounts of experienced anxiety.

A coefficient of correlation between the Math Test Anxiety Scale and the Numerical Task Anxiety Scale was computed to determine if the scales were independent. The $r = .32$ ($n = 197$) indicated that while some common variance (10%) was present, the small amount indicated that the scales were partially independent.

Analysis of variance procedures indicated that there were no significant differences among Factor 1 or Factor 2 scores in terms of age, sex, race, location of residence, total family income, and whether encouraged to take or discouraged from taking math courses. However, the ANOVA procedures (applied to Factor 1 scores only) revealed that students who had taken Algebra II in high school experienced significantly less math anxiety than students who had not taken Algebra II ($F = 10.70$; $p < .001$). In addition, students who had A's and B's in high school Algebra or in high school Geometry experienced significantly less math anxiety than students who reported making C's, D's, or F's in high school Algebra ($F = 2.76$; $p < .05$) or in high school Geometry ($F = 3.65$; $p < .01$). These findings are consistent with findings reported by Betz (1978) indicating that math anxiety

occurs frequently among students with inadequate math backgrounds.

Discussion

The present study has attempted to determine if math anxiety is a unidimensional or multidimensional construct. If, indeed, math anxiety did emerge as a multidimensional construct then the independent dimensions of the construct would be identified. Those independent dimensions would then be the basis for determining if differences exist among math anxiety scores in terms of personal and background variables.

Two meaningful dimensions emerged. The first, Math Test Anxiety, accounted for the largest part of the variance (33%). The second dimension, Numerical Task Anxiety, accounted for only 7 % of the variance. That there does appear to be a single primary dimension is a finding which may have implications for more clearly understanding the phenomenon of math anxiety. Math anxiety is presently conceptualized as tension and anxiety that interfere with the solving of math problems in ordinary life and academic situations. While the secondary dimension identified in this study (Numerical Task Anxiety) seems to be consistent with that definition, the primary dimension which accounted for more than four times as much variance is not even implicated in that definition or any other definition. Findings in this study do indicate that present definitions of math anxiety should be modified to include apprehension about taking math tests and about receiving the outcome of math evaluations. Recent studies (Resnick, Viehe, and Segal, 1980; Rounds and Hendel, 1980) have

very consistently identified math test anxiety to be a major component of math anxiety.

As colleges and universities mandate specific math course requirements as a pre-condition for admittance to higher education, it seems clear from the results obtained in this study that student performance (in the math courses) should be monitored in high school. Students most likely to experience math anxiety in college seem to be students who do more poorly in high school math and who are inadequately prepared. Appropriate and early intervention could reduce the likelihood that students will experience math anxiety in subsequent high school math classes and in college math classes.

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APPENDIX

Table 1

Illustrative MARS Items With Factor Loadings For Factor 1

MARS Item	Factor Loading
34. Studying for a math test.	.73
35. Starting a new chapter in a math book.	.75
43. Taking math section of college entrance exam.	.72
53. Taking an exam (quiz) in a math course.	.76
54. Taking an exam (final) in a math course.	.74
71. Picking up the math text book to begin working on a homework assignment.	.71
72. Being given a homework assignment of many difficult problems which is due next class meeting.	.77
73. Thinking about an upcoming math test one week before.	.74
74. Thinking about an upcoming math test one day before.	.69
75. Thinking about an upcoming math test one hour before.	.61
76. Thinking about an upcoming test five minutes before.	.62
78. Waiting to get a math test returned in which you expected to do well.	.68
85. Receiving your final math grade in the mail.	.71
88. Getting ready to study for a math test.	.62

Table 2

MARS Items With Factor Loadings For Factor 2

MARS Item	Factor Loading
5. Dividing a five digit number by a two digit number in private with pencil and paper.	.58
13. Totaling up the dues received and the expenses of a club you belong to.	.52
14. Adding up 976 + 777 on paper.	.66
30. Watching someone work with a calculator.	.49
47. Reading a cash register receipt after your purchase.	.56
48. Figuring the sales tax on a purchase that costs more than $1.00.	.48
90. Figuring out your monthly budget.	.48

Table 3

Items Comprising Math Test Anxiety Scale with Means and Standard Deviations

MARS Item	Mean	SD
34. Studying for a math test.	2.59	1.30
35. Starting a new chapter in a math book.	2.00	1.16
43. Taking math section of college entrance exam.	2.59	1.35
53. Taking an exam (quiz) in a math course.	2.53	1.28
54. Taking an exam (final) in a math course.	3.17	1.51
71. Picking up the math textbook to begin working on a homework assignment.	1.87	1.12
72. Being given a homework assignment of many difficult problems which is due the next class meeting.	2.78	1.33
73. Thinking about an upcoming math test one week before.	2.46	1.28
74. Thinking about an upcoming math test one day before.	3.02	1.41
75. Thinking about an upcoming math test one hour before.	3.21	1.52
76. Thinking about an upcoming math test five minutes before.	3.30	1.56
78. Waiting to get a math test returned in which you expected to do well.	2.68	1.43
79. Waiting to get a math test returned in which you expected to do poorly.	3.21	1.46
82. Picking up a math textbook to begin a difficult reading assignment.	2.36	1.22
85. Receiving your final math grade in the mail.	2.85	1.43
88. Getting ready to study for a math test.	2.08	1.15
91. Being given a "pop" quiz in a math class.	2.73	1.36

Table 4

Items Comprising Numerical Task Anxiety Scale With Means and Standard Deviations

MARS Item	Mean	SD
5. Dividing a five digit number by a two digit number in private	1.20	.68
13. Totaling up the dues received and the expenses of a club you belong to.	1.62	.95
14. Adding up 976 + 777 on paper.	1.16	.56
30. Watching someone work with a calculator.	1.24	.69
47. Reading a cash register receipt after your purchase.	1.23	.66
48. Figuring the sales tax on a purchase that costs more than $1.00.	1.38	.76
90. Figuring out your monthly budget.	1.72	1.01

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